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An Exploratory Investigation of the Cooling Drag Associated with General Aviation Propulsive Systems - Part II

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The Cooling Drag program currently involves two specific efforts; a continuation of the literature research leading to further development of an installation design manual for horizontally opposed engines, and a flight test program utilizing the Piper PA-41P Propulsion System Research Vehicle (PSRV) to investigate the influence of conventional inlets and exit configurations on cooling. The current status and projected activity for each of these are discussed in the following paragraphs.

The literature research is approximately 2/3 complete. Most of the pertinent material identified are various NACA reports with the remainder consisting of technical journals. A visit to Wright-Patterson AFB was made to search for applicable WADC and AMC reports. No reports were found due to either having been destroyed or placed in storage in St. Louis where they are, for all practical purposes, inaccessible. A trip will be made shortly to the DDC library to search for these reports.

The material found to be most applicable to the horizontally opposed geometry concerns the Ranger inline aircooled engine development during World War II. Contact has been made with key personnel involved in this program and an effort will be made to acquire copies of existing documentations. The remaining literature search will be directed towards European technical journals and developmental reports. The prime source at the moment appears to be Bristol Siddeley in England.

The PSRV aircraft is currently undergoing modifications to test configuration and is expected to be flying by mid-February. The alterations to the right nacelle are illustrated by Figures 1 and 2, and the engine pressure and temperature instrumentation is shown in Figure 3. The major modification consists of relocating the oil cooler and accessory blast tubes and isolating their respective air flow from that of the engine. Accordingly,

the cooling mass flow of the engine will be measured by a nose piece with a sufficiently long inlet duct. Also shown in Figure 2 is the propeller wake rake to sense the total pressure distribution for comparison with that at the inlet. Figure 3 shows the locations of the pressure tubes and thermocouples on the engine. The extensive pressure survey in the plenum is to investigate the causes of the relatively low pressure recovery which were discovered in the T-34 program. In addition, three nose pieces are being fabricated; existing swept inlet, short duct inlet, and long duct inlet. The data acquisition system is basically the same as that of the T-34 program, except that the temperature channels have been expanded from 25 to 48, and the higher quality signal conditioning amplifiers are being utilized.

The PSRV flight test program will involve four areas of investigation; inlets, plenum, exits, and cooling mechanics. Three inlet configurations will be tested; the existing swept inlet, a short duct inlet, and a long duct mass flow metering inlet. The exterior static pressure distributions about all three inlets will be recorded. The influence of the inlets on the pressure recovery distribution in the plenum will be of prime concern. For each inlet, different configurations of plenum baffling will be tested.

The first phase of the flight test program will concentrate on the inlet and plenum pressure recovery studies. All flights will be at the same density altitude, in the neighborhood of 6000 feet. During this phase, nacelle static pressure distribution measurements will be made in order to locate the upper surface exits. During the second phase, the long duct inlet will be used, and cooling data will be recorded throughout the altitude/airspeed envelope of the aircraft. Also, exit studies will be

performed at this time to obtain a direct comparison between lower and upper surface locations.

At present, the flight test program is one month behind schedule. Due to the nature of the tests, there is less dependency on early morning smooth air conditions than with the T-34 program, and the delay can be made up in the flight operation phase.

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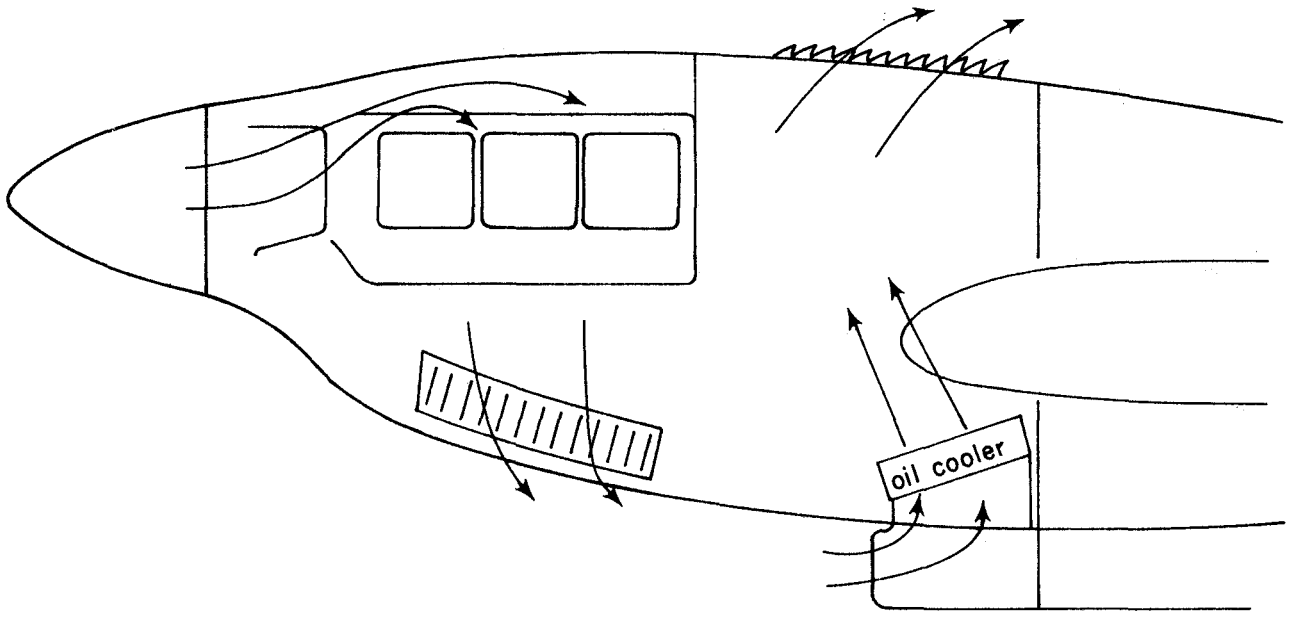

Figure 1. Original installation with internal oil cooler and louver exits.

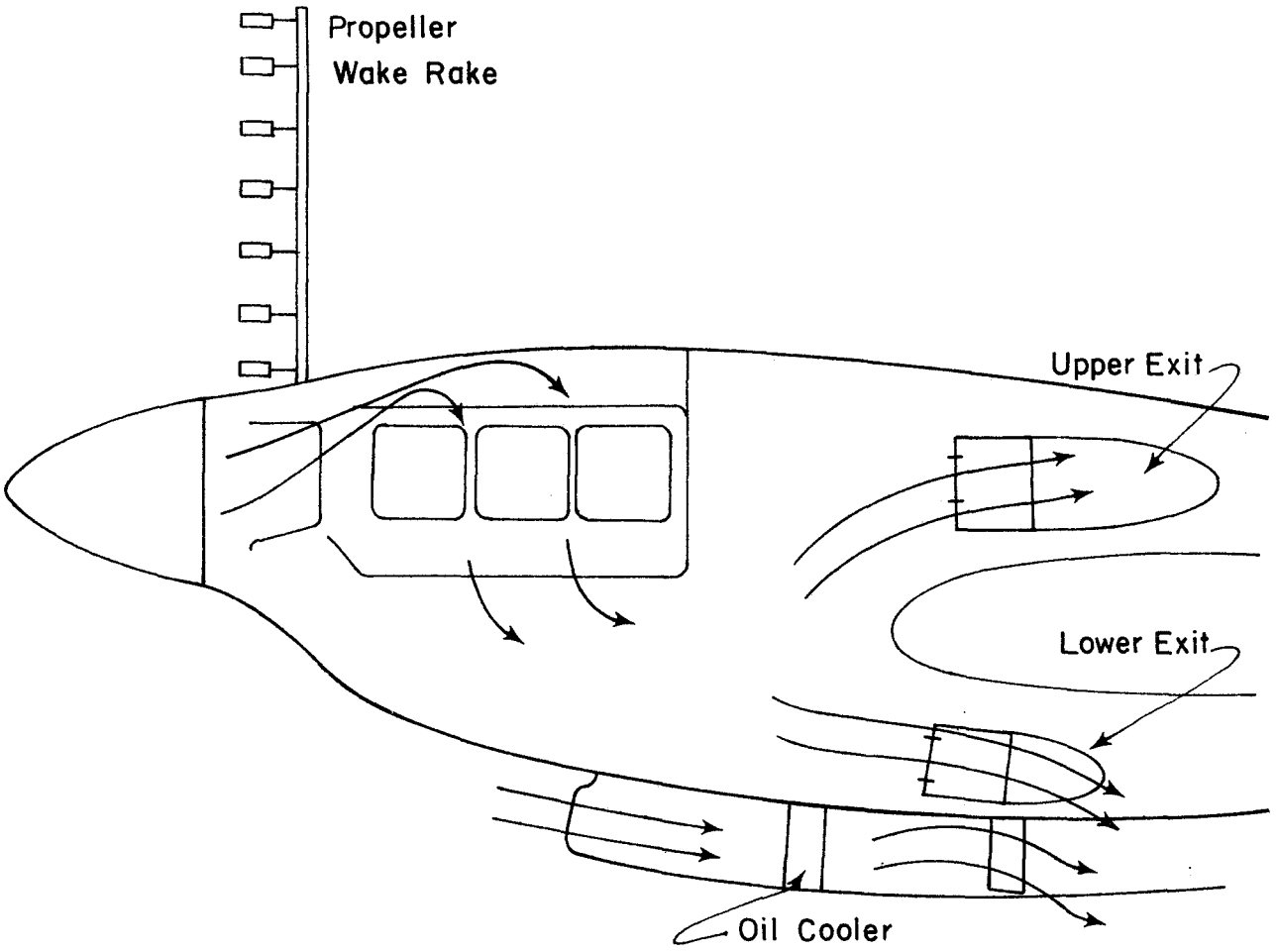

Figure 2. Modified installation with upper and lower cowl flap exits and propeller wake rake.

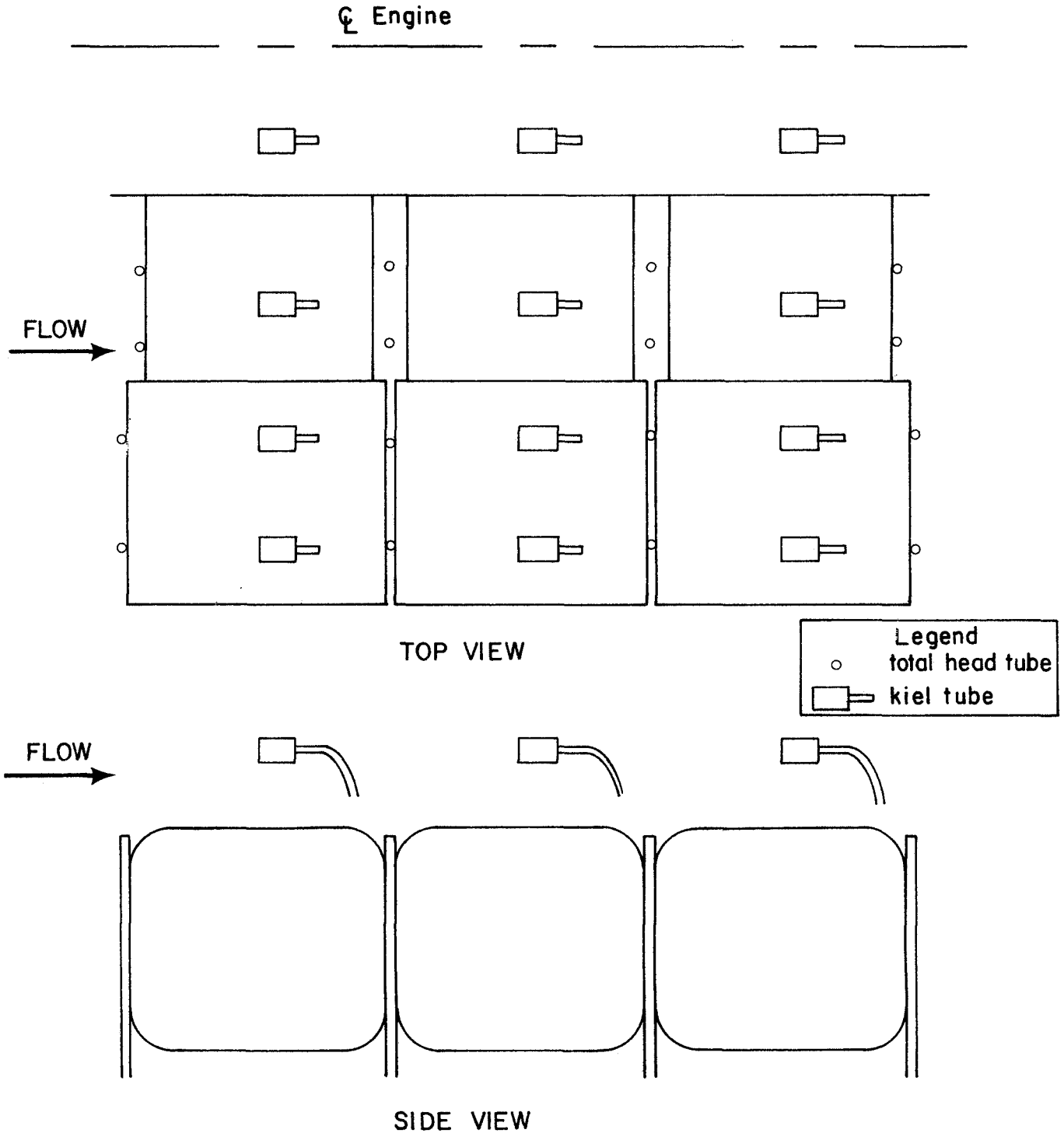

Figure 3. Engine pressure and temperature instrumentation.

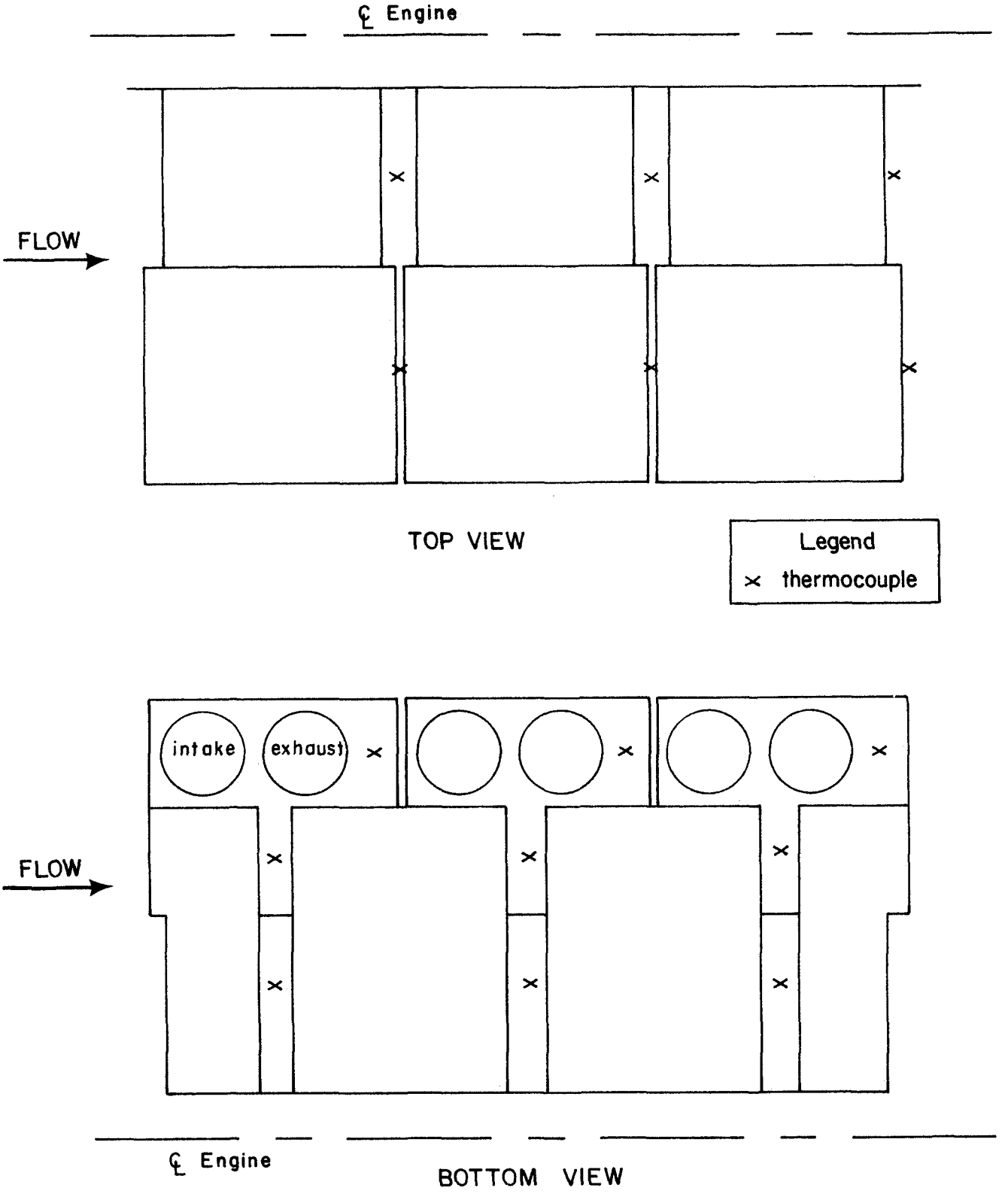

Figure 3. Continued.